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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PR 4009 for a patent by FOCUS THERMAL TECHNOLOGIES (INTERNATIONAL) LIMITED filed on 28 March 2001.

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Nineteenth day of April 2002

J. Billingsley

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PROVISIONAL SPECIFICATION

Thermal Storage Device

Field of the Invention

The present invention relates to thermal storage devices and in particular to the off-peak provision of refrigeration for subsequent use.

Background

It has been know to freeze water or other suitable medium during periods of low thermal load and then draw upon the ice bank subsequently when required loading and costs may be higher. Not only does this provide a low-cost means of cooling but the substantially constant temperature of the ice can be utilised to provide a constant process temperature.

One known form of thermal storage device employs a number of spaced grids of refrigerant pipes extending between inlet and outlet manifolds. The grids are closely packed within a water tank and over a period of around eight hours they freeze most of the water within the tank into a solid block of ice. when the process is reversed, water is passed through the tank around the periphery of the block which progressively melts and chills the water.

These known devices suffer from various shortcomings. Because the ice block is initially one solid mass, only its outer surface is exposed initially to the water flow. This flow can also by-pass the block by fast tracking to the tank exit as the ice melts. This melting can also occur in an irregular manner causing further inefficiency. Attempts to promote water circulation involve agitation by aeration or paddle which add complexity and reduce efficiency.

Another disadvantage is that the spaced grids of refrigerant piping cannot easily be changed. This may be necessary for repair but also for changing the pipe material to suit different refrigerants. For example, copper is unsuitable for use with ammonia.

It is an object of the present invention to overcome or at least ameliorate some of these disadvantages of the prior art.

Summary of the Invention and Object

According to a first aspect of the invention there is provided a refrigeration device including:

a substantially cylindrical tank having sidewalls, a fluid inlet and a fluid outlet; and one or more refrigeration evaporator pipes helically disposed within the tank for freezing fluid adjacent the pipes;

the pipes being positioned with respect to the sidewalls such that the tank and frozen fluid together define a substantially helical path for the flow of heat exchange fluid from the inlet to the outlet.

The invention also includes a method of operating a device as described above including the steps of allowing sufficient fluid to freeze on the surfaces of the evaporator pipes to define the helical path with periodic hot gas injection from the refrigeration compressor into the evaporator pipes to crack the ice mass allowing better heat transfer from the water in the tank for freezing and then allowing heat exchange fluid to flow along the path to transfer heat to the frozen fluid as it re-melts.

The invention also includes the possibility of recovering heat extracted from the water being chilled to ice and using it to heat water for other uses.

Preferably, the tank is a right cylinder having a circular cross-section and the refrigeration pipes form a regular helix. The tank is also preferably annular in section, having a central cylindrical column which both supports the refrigeration pipes and defines an inner sidewall for the operative part of the tank.

Preferably, the device includes two concentrically disposed refrigeration pipes, each in the form of a regular helix of identical pitch but of differing radii.

Preferably, the two helices are axially positioned such that in section taken on a plane including the tank axis the two pipes are always substantially disposed on a common radial line.

In other embodiments the tank may be of non-circular cross-section with corresponding changes to the helix.

Brief Description of the Drawings

In order that the invention may be more readily understood, preferred embodiments of the invention will now be described with reference to the accompanying drawings in which :

Figure 1 is a sectional side elevation of a refrigeration device according to the invention.

Figure 2 is a sectional plan view taken on line 2-2 of Figure 1.

Figure 3 is a sectional side elevation of the refrigeration device according to the invention with a slightly changed evaporator coil disposition to ease manufacture

Figure 4 is a schematic layout of the refrigeration circuit used to chill the water to ice and recover waste heat.

Description of Preferred Embodiments

A preferred embodiment of the invention will now be described, by way of example only.

Referring to the drawings Figures 1 to 3, the refrigeration device 10 includes a right cylindrical tank 11 having a central cylindrical column 12 defining an annular operative chamber 13 bounded by outer and inner sidewalls 14 and 15 respectively

The tank is positioned vertically about an axis 16 and includes a water inlet 17 adjacent the top of the tank and a corresponding outlet 18 at the bottom.

The central column 15 supports a pair of refrigeration pipes 19 and 20 each concentrically disposed in the form a regular helix of identical pitch but of differing radii. The two helices are axially positioned such that in section taken on a plane including the tank axis the two pipes are always substantially disposed on a common radial line as shown.

Preferably the pipes are horizontally spaced in section as illustrated but the invention will still operate though less efficiently if only a single refrigerant pipe is used or in the case of two or more pipes if these are not horizontally aligned.

In use, the tank is filled almost completely with water and the refrigerant coils are operated as an evaporator to freeze the water adjacent the pipes. As this freezing process continues the growing ice helices bridge the gap between the refrigeration pipes and coalesce into a single ice helix. The pipes are positioned with respect to the tank sidewalls such that the freezing process can be permitted to continue until the ice helix touches or almost touches one or both of the inner and outer sidewalls. This stage can be determined by suitably placed probes for detecting ice growth, for example by changes in resistance between the liquid and solid phases.

The over freezing of the ice mass may also be detected by the placement of thermocouples in areas where the ice mass is to stop forming. Once the temperature of these thermocouples falls below freezing point the ice mass has progressed to its design limit and the refrigeration plant is shut down.

It has been found that if the thermocouples are repetitively frozen in the ice mass they may become damaged and unreliable. This defect has been ameliorated by placing the thermocouples in a metal tube which is partially filled with a low freezing point liquid such as ethylene glycol to effect heat transfer to the thermocouples thus enabling the thermocouples to sense temperatures below the freezing point of water without the thermocouples being subjected to the stress of being embedded is a frozen fluid.

During the freezing of the ice helix the ice formed around the helical evaporator tubes increases in thickness and forms an insulation barrier to the further transfer of heat from the water in the tank to the evaporator tube thus slowing down the rate of ice growth. It has been found that of the evaporator tube is suddenly heated the ice growth on the tube may be cracked allowing water paths through fissures in the ice to the evaporator tube thus improving the heat transfer and allowing a more rapid growth of the ice layer around the tube.

Referring to Figure 4 this sudden introduction of heat into the evaporator tube is accomplished by means of hot gas injection from the refrigeration compressor. The refrigeration circuit typically includes a compressor 41, suction accumulation vessel 43, oil trap 42, condenser 44, thermostatic expansion valve 46 and the evaporator tube 45 which is immersed in the thermal storage tank 48. The thermostatic expansion valve is typically controlled by sensing the exit temperature of the refrigerant from the evaporator tube by means of a sensor 49 to control the ice temperature which is typically set at –10 degrees Celsius.

When the ice has built up to the stage where the heat transfer from the chilled water to the evaporator tubes is impaired thus slowing the rate of ice formation the control valve 47 is opened for a short period of time to inject hot gas from the refrigeration compressor direct into the evaporator tube thus raising its temperature very rapidly. This has been found to crack the ice formation and improve the rate of ice formation when to control valve 47 is closed and the evaporator temperature is controlled once again by the thermostatic expansion valve.

This hot gas injection may be controlled on a time basis throughout the freezing cycle or alternatively by means of sensors which detect the rate of ice build up or heat removal from the chilled water. Such a sensor might be a monitor on the refrigeration circuit to measure the rate of heat rejection at the condenser.

The heat rejected at the condenser may be recovered to heat water for other uses within the establishment where the thermal storage device is installed. This may be accomplished by using a heat exchanger 51 as a condenser for the refrigeration unit with the water to be heated entering the heat exchanger through the inlet 52 and leaving through the outlet 53.

The flexibility of the refrigeration circuit may be improved by the addition of three way valves 50 to give the option of using either a regular air cooled condenser 44 which may be a cooling tower or alternatively using the hot water heat exchanger as a condenser. This may be required as the temperature of the water being heated for other uses rises to a level where the efficiency of the refrigeration unit is adversely affected

Once the ice helix has been formed the thermal storage tank is ready for use as a chiller by passing water through the tank from the inlet 17 to outlet 18. In accordance with the invention the ice helix together with the tank sidewalls define a substantially helical path for the water as it passes through the tank. This path is well defined and free-flowing in a way which reduces the tendency for the water to by-pass the helix adjacent the tank sidewalls.

It is also apparent that the water flow is in constant heat exchange contact with the ice over a substantially constant distance much greater than the length of the tank. For example, in one embodiment a tank of 1.9 metres in length can produce 44 metres of helical path.

Water flow along the helix is promoted by an appropriately directed inlet nozzle 21 and outlet 18. Because of the substantially constant temperature of the ice, provided the water flow is not excessive it can be supplied at a substantially constant depressed temperature of around 0.5 degrees Celsius.

The water temperature may be further depressed to below 0 degrees Celsius by adding a quantity of a substance such as ethylene glycol to the chilled water supply to depress the freezing temperature of the chilled water below 0 degrees Celsius.

The tank may be formed of any suitable material such as polyethylene. The central column can be polyvinylchloride piping and serves to support the refrigerant pipes by means of a plurality of copper brackets 22. The tank may include a removable lid 23 to permit easy access to the helical pipes which can be removed integrally with the central column. Thus, the refrigeration pipes can be easily removed for inspection, cleaning or replacement.

In other embodiments the tank may be of non-circular cross-section with corresponding changes to the helix so that the ice can interact efficiently with the adjacent sidewalls. The central column can also be omitted, though with an increased tendency for water by-passing the ice helix.

The tank may also be operated in a horizontal configuration. This is less desirable because higher flow pressures are required to compensate for the loss of gravity feed. It is also more difficult to produce a complete ice helix since the tank must desirably be full of water in its horizontal configuration and this involves additional means to provide for expansion of the ice on freezing.

The thermal storage device described above is well adapted for use in many applications requiring chilled water. This includes industrial and agricultural processes such as beverage chilling, air-conditioning and food processing. The unit may be used to replace air-conditioning cooling towers without the need for special chemicals to control legionella bacteria. The system can be totally sealed from outside influences.

~~MasterCool International Pty Limited~~

Focus Thermal Technologies (International) Limited

This provisional should be lodged without claims. The following is a potential claims strategy that might be followed. At examination it may be necessary to combine some of the subsequent claims into the primary claim to appease the examiner if he believes the invention has been pre-published or lacks an inventive step.

Claims

1. A thermal storage device with a helical ice and chilled water path
2. As in Claim 1 with detectors to shut down at the design ice thickness
3. As in Claims 1 to 2 with hot gas injection to enhance the rate of ice formation
4. As in Claims 1 to 2 with waste heat recovery for the heating of water

Left over second invention

In one particular embodiment the invention is well adapted to the simultaneous chilling of a number of different beverages at point of sale. According to this further aspect of the invention there is provided a heat transfer device for transferring heat between a first fluid circuit and a plurality of second fluid circuits, the device including:

a tank, an inlet manifold for the first fluid and a plurality of first pipes extending from the manifold into the tank and each having at least one discharge outlet within the tank, an outlet from the tank, a corresponding plurality of second pipes for the second fluid, each extending through the tank adjacent its corresponding first pipe, each second pipe being in close heat transfer relationship with first fluid discharged from its first pipe.

Preferably, each first pipe is straight and includes at least one discharge outlet at its end directed back along its length. The corresponding second pipe is helically disposed around the first pipe substantially in the path of the discharged fluid.

In other embodiments the discharge outlets are spaced along the first pipe and directed radially outwardly towards the surrounding second pipe.

This embodiment is illustrated in Figure 3.

Referring to the drawing, the heat transfer device 30 includes a cylindrical tank 31 having a chilled water inlet manifold 32 and a number of chilled water pipes 33 extending from the manifold into the tank. Each water pipe 33 includes discharge outlets 34 at its far end for directing chilled water back along its length.

A like number of beverage pipes 35 traverse the tank in close heat transfer relationship with corresponding chilled water pipes 33. The beverage pipes are preferably helically disposed around their corresponding chilling pipe substantially in the path of its discharged fluid. In other embodiments the discharge outlets are spaced along the chilling pipe to direct chilling fluid radially outwardly towards the surrounding beverage pipe.

Chilled water enters the beverage chiller manifold at inlet 37 and leaves the tank through outlet 38 from whence it returns for further cooling by recirculation through the thermal storage unit described above. The outlet is preferably angled tangentially to promote additional circulation within the chiller tank.

It will be appreciated that the illustrated chiller can be used with a number of different beverages which are each individually chilled as required.

Although the invention has been described with reference to specific examples it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

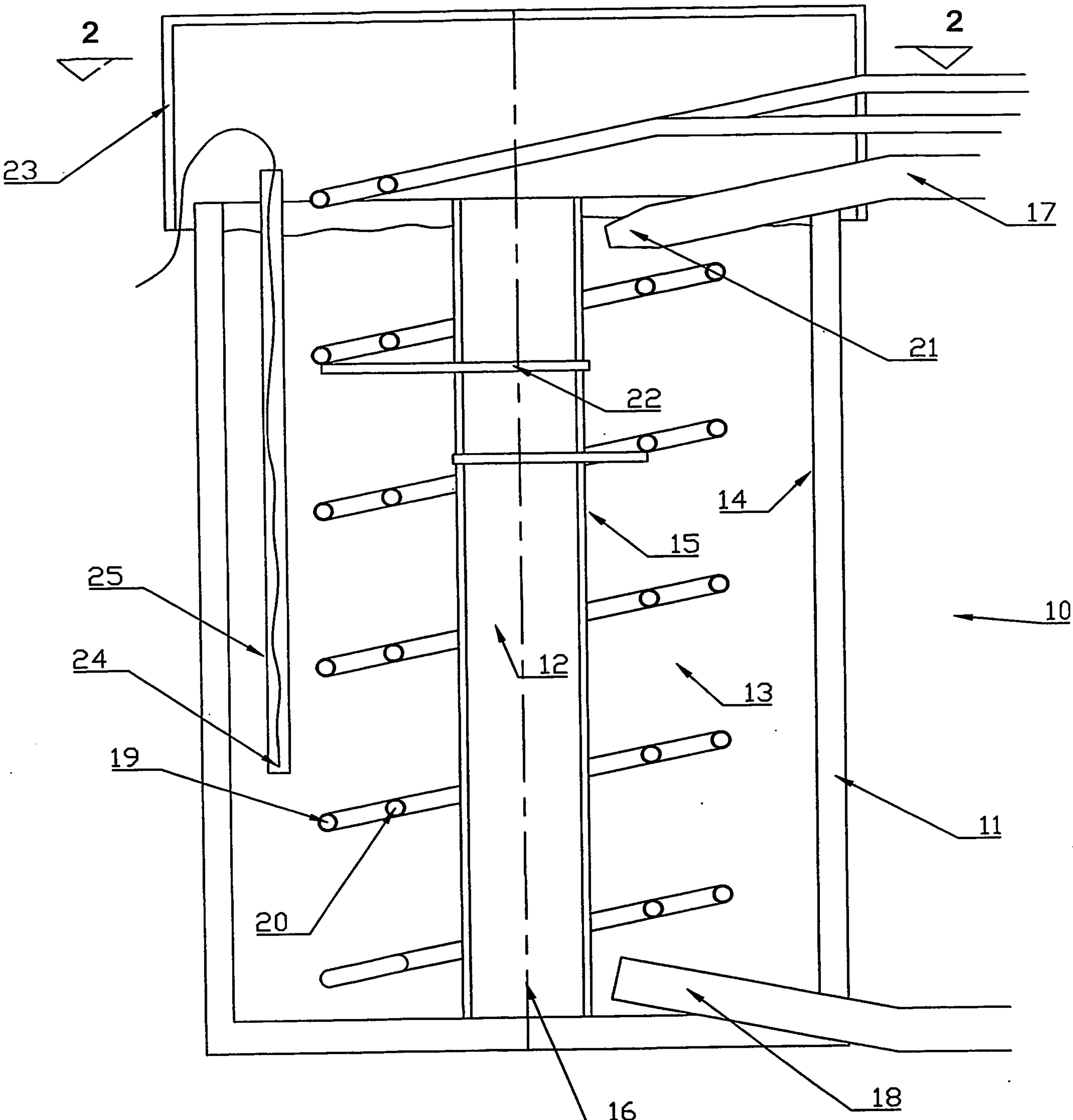

Figure 1

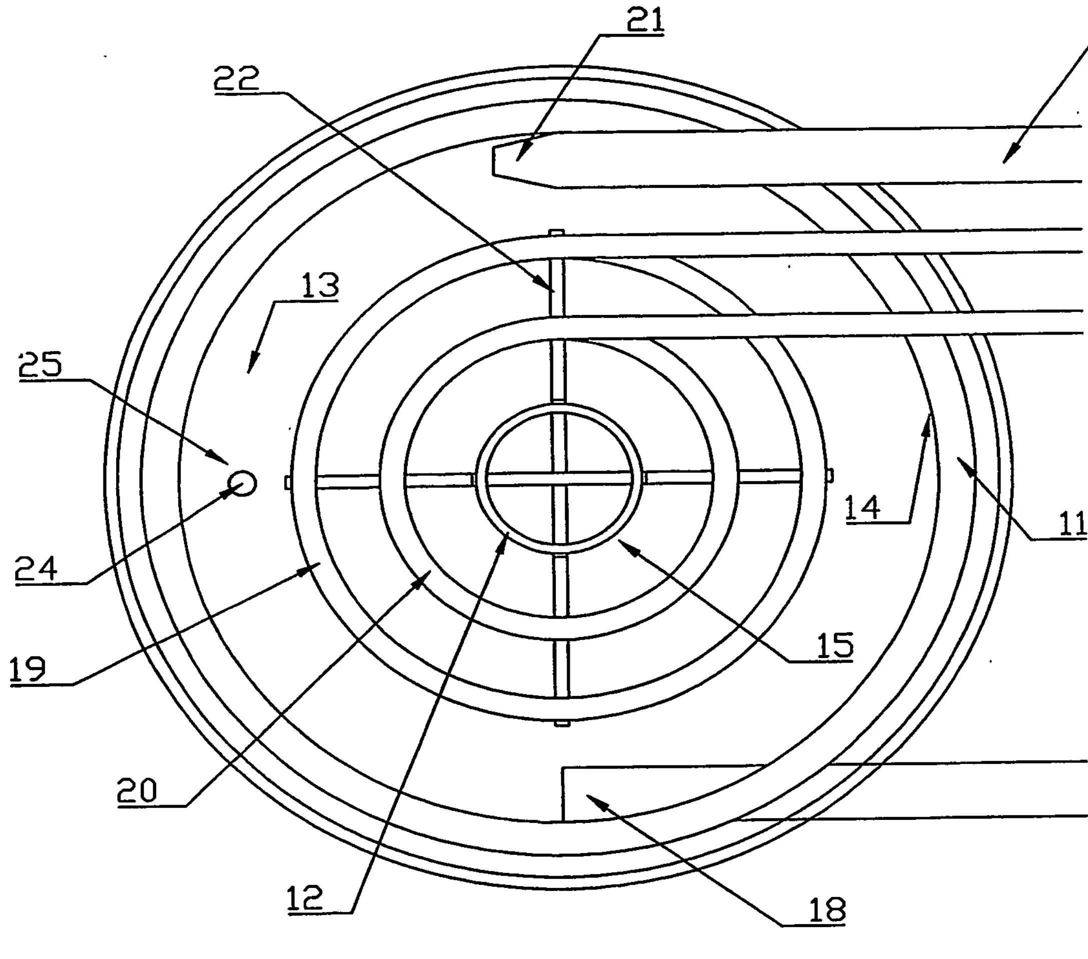

Figure 2

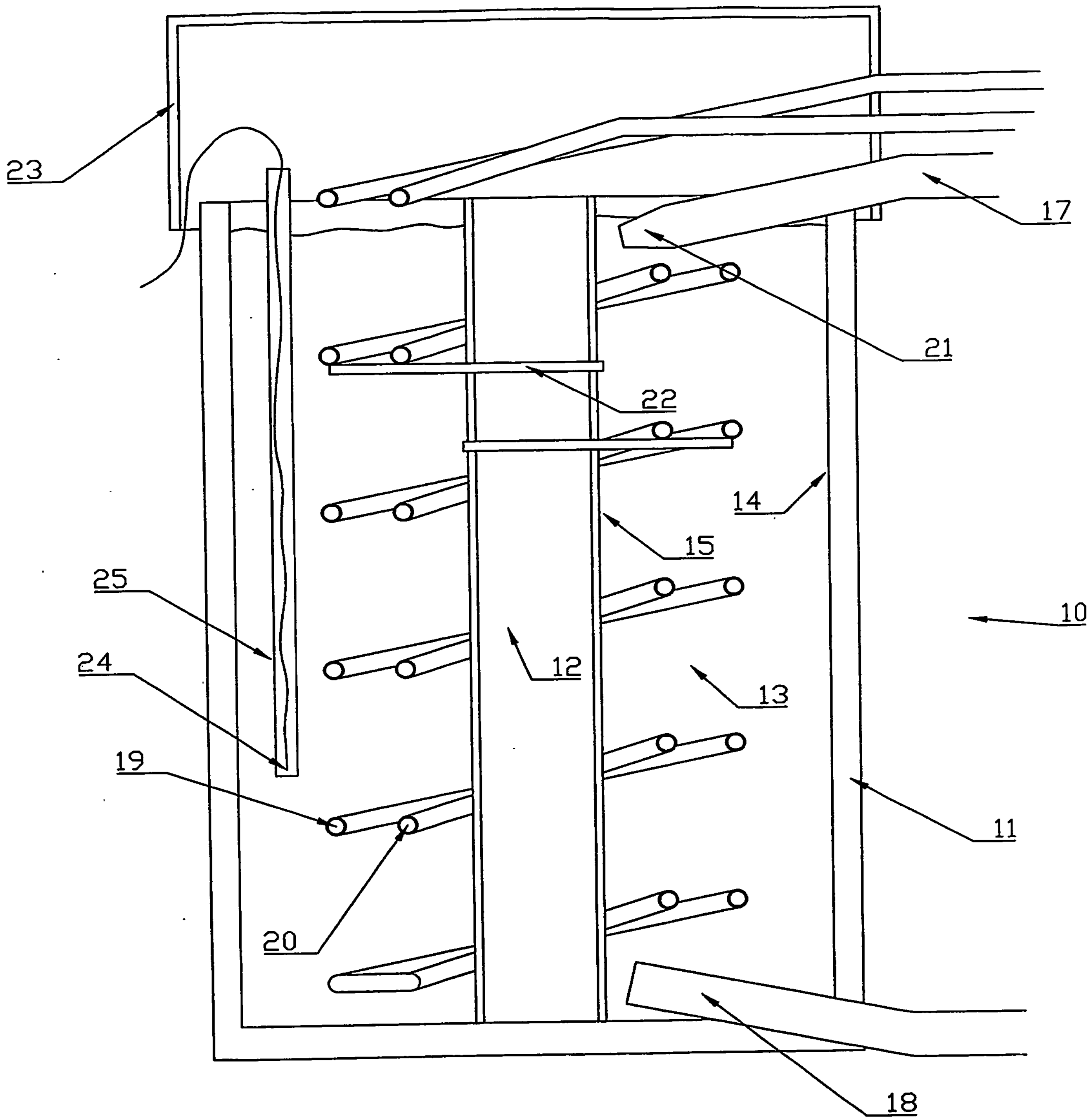

Figure 3

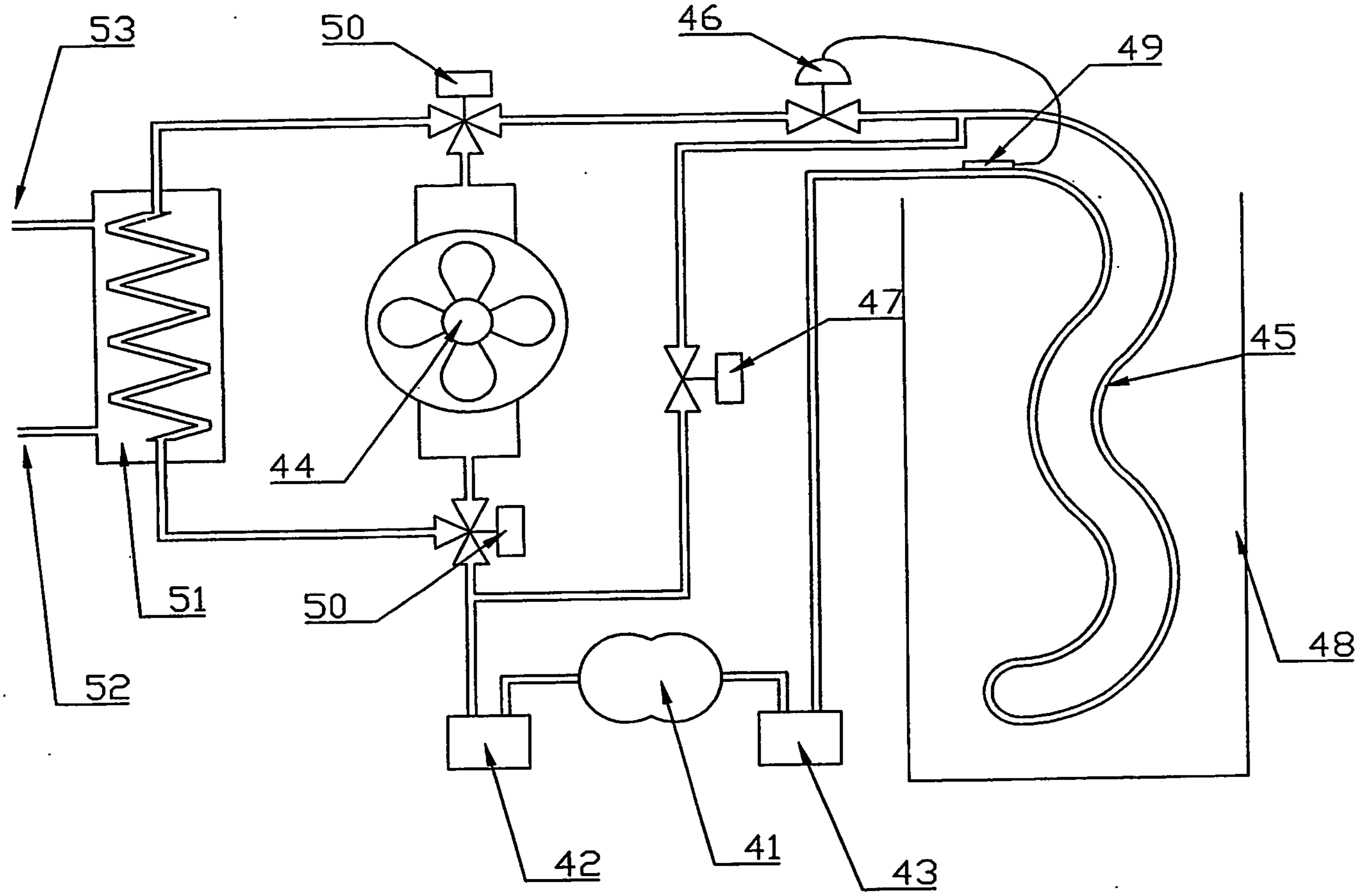

Figure 4